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## FULL-LENGTH REPORT



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# The influence of chronological age on cognitive biases and impulsivity levels in male patients with gambling disorder

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## ABSTRACT

**Background and aims:** Due to the contribution of age to the etiology of gambling disorder (GD), there is a need to assess the moderator effect of the aging process with other features that are highly related with the clinical profile. The objective of this study is to examine the role of the chronological age into the relationships between cognitive biases, impulsivity levels and gambling preference with the GD profile during adulthood. **Methods:** Sample included  $n = 209$  patients aged 18–77 years-old recruited from a Pathological Gambling Outpatients Unit. Orthogonal contrasts explored polynomial patterns in data, and path analysis implemented through structural equation modeling assessed the underlying mechanisms between the study variables. **Results:** Compared to middle-age patients, younger and older age groups reported more impairing irrational beliefs ( $P = 0.005$  for interpretative control and  $P = 0.043$  for interpretative bias). A linear trend showed that as people get older sensation seeking ( $P = 0.006$ ) and inability to stop gambling ( $P = 0.018$ ) increase. Path analysis showed a direct effect between the cognitive bias and measures of gambling severity (standardized effects [SE] between 0.12 and 0.17) and a direct effect between impulsivity levels and cumulated debts due to gambling (SE = 0.22). **Conclusion:** Screening tools and intervention plans should consider the aging process. Specific programs should be developed for younger and older age groups, since these are highly vulnerable to the consequences of gambling activities and impairment levels of impulsivity and cognitive biases.

## KEYWORDS

cognitive biases, gambling disorder, impulsivity, older age, path analysis, younger age

## INTRODUCTION

### Epidemiological data for gambling disorder

Systematic reviews of epidemiological studies have shown significant increases in the prevalence of gambling disorder (GD) worldwide during the last decades, with cross-sectional estimates (over the last 12 months) around of 0.1–6% in the general population in developed countries (Calado & Griffiths, 2016). Prevalence studies also warn of a potentially greater risk of problematic gambling in the near future among all sectors of the population as a result of the prevalent ease accessibility to gambling platforms and the increase in the opportunity to gamble (Suisa, 2015). Furthermore, there is an awareness of the high-vulnerability of two age groups for the onset and intensification of the disordered gambling: during adolescence (even at ages when bets on gambling is illegal) and early adulthood stages (Giralt et al., 2018), and among the elderly (Subramaniam et al., 2015; Tse, Hong, Wang, & Cunningham-Williams, 2012). These disturbing reports have led to the appearance of new empirical research in order to provide a comprehensive view of the GD phenotypes. New studies should be focused on the most high-risk groups, and on the analysis of the multivariate relationships between several risk factors (including interaction and mediational effects).

### Relevance of cognitive performance on the GD profiles

Cognitive biases related to gambling behavior are a classical and challenging area for the study of GD. Patients with GD systematically report relevant cognitive distortions related with the onset of problematic gambling, its maintenance and the difficulty overcoming this dependence. Studies have shown that irrational thoughts are pervasive in most forms of problematic gambling, and that a number of erroneous beliefs held by GD patients seem to affect their capacity to estimate the real chances of winning, and seriously condition their fallibility of decision making mechanisms (Mallorqui-Bague et al., 2019; Verdejo-Garcia, Alcazar-Corcoles, & Albein-Urios, 2019). The cognitive approach to problematic gambling has identified several types of cognitive biases (Clark, 2010; Clark & Limbrick-Oldfield, 2013; Goodie & Fortune, 2013; Lévesque, Sévigny, Giroux, & Jacques, 2018), which finally give rise to an “illusion of personal control” over the game. Gamblers usually overestimate their capacity of control and can even confuse chance games with games of skill. This results in a perception of expected value of gambling as a positive when expected value is really negative. Studies have systematically observed that GD patients usually overvalue recent results when evaluating the chances of a certain outcome occurring (recency bias). They only seek out information that supports what is called gamblers initial gut decision in ignoring evidence to the contrary that might be a red flag to a given decision (confirmation bias). Likewise, they may believe that a win is necessarily due after a series of loses (gambler’s fallacy or near-miss effect [unsuccessful outcome is proximal to a win]). The frequency

and intensity of the gambling severity and the continuation of the gambling activity is even justified by gamblers, arguing that they are learning and developing the required skills/abilities to win (Chrétien, Giroux, Goulet, Jacques, & Bouchard, 2017; Emond & Marmurek, 2010; Kovács, Richman, Janka, Maraz, & Ando, 2017; Leonard & Williams, 2016). At a psychological level, it has been postulated that these cognitive distortions related to the gambling severity could be explained by three main mechanisms. The first hypothesis should be the generic poor capacity of humans themselves in processing probability/chance and judging randomness (Williams & Griffiths, 2013; Yu, Gunn, Osherson, & Zhao, 2018). The second hypothesis refers to the specific structural characteristics of some games that could promote cognitive distortions (e.g., the stimuli of bright flashing lights and loud noises of slot-machine that accompany each win) (Myles, Carter, & Yucel, 2019). And thirdly, psychobiological approaches show that cognitive biases in GD could be the result of the brain reward functions: a) neurochemical research has related dysregulation in serotonin, noradrenaline, and glutamate functions with poor decision-making performance (van Timmeren, Daams, van Holst, & Goudriaan, 2018); and b) functional neuroimaging studies and neuropsychological measurements of impulsivity and risky decision-making have revealed damage in the brain function of GD patients (mainly in the ventromedial prefrontal cortex and striatum), as well as impairments in the executive functions (van Holst, van den Brink, Veltman, & Goudriaan, 2010). Research in the cognitive area also evidences that aging is strongly related with declines in cognitive abilities, which could render older adults highly susceptible to many cognitive biases (Miquel et al., 2018). Since these deviations from rationality in judgments could moderate the relationship between age and the final decision-making outcomes (Bangma, Fuermaier, Tucha, Tucha, & Koerts, 2017; Bruine de Bruin, Parker, & Fischhoff, 2012), it has been postulated that aging-related cognitive decline greatly impacts older adults’ daily life, including their GD profile (Paolini, Leonardi, Visani, & Rodofili, 2018). But despite the promising results in this area, it remains unclear how chronological age influences the direction, strength/s, and precise mechanisms of the relationships between cognitive styles and problematic gambling-related behaviors.

### Relevance of impulsivity as a core mechanism in the GD area

Another core concept to understanding GD profile is impulsivity, currently considered as a complex multidimensional construct explaining behaviors that may be unduly hasty, risky, and/or inappropriate, leading to negative outcomes. Recent models of impulsivity address both its behavioral manifestations and the underlying brain-based mechanisms, and highlight that many psychopathological conditions (including behavioral addictions) require the description of the impulsivity as a core mechanism (Lee, Hoppenbrouwers, & Franken, 2019; Sharma, Markon, & Clark, 2014; Tiego et al., 2019). In fact, GD has been



commonly listed alongside the impulse control disorders, largely as a consequence of the high level of personality traits related to impulsivity reported by GD patients (such as novelty/sensation seeking, lack of perseverance/premeditation, or positive/negative urgency), and by the results of the neurobiological models measuring the relationship between impulsivity levels and gambling activity (Chamberlain, Stochl, Redden, & Grant, 2018; Ioannidis, Hook, Wickham, Grant, & Chamberlain, 2019; Maclaren, Fugelsang, Harrihan, & Dixon, 2011; Rochat, Billieux, Gagnon, & Van der Linden, 2018). Although few studies have addressed the structure of impulsivity in problematic and disordered gambling (Gullo, Loxton, & Dawe, 2014; Hodgins & Holub, 2015; Kräplin et al., 2014; MacKillop et al., 2016), the analysis of the impulsivity levels in different personality domains has received much attention. Along this line, large cross-sectional associations have been found between measurements of impulsivity and gambling severity (including the level of gambling symptoms, frequency of gambling activity, bets per gambling-episodes, or even debts due to the gambling practices) in both clinical and population-based samples (Black et al., 2015; Grall-Bronnec et al., 2012; Yan, Zhang, Lan, Li, & Sui, 2016). Several pioneer longitudinal studies have also suggested that impulsivity levels during childhood may have a predictive capacity on the problematic gambling in emerging adulthood (Dussault, Brendgen, Vitaro, Wanner, & Tremblay, 2011). For example, the literature has highlighted the robust link between behavioral addiction and neurodevelopmental disorders characterized by inattention and hyperactivity-impulsivity, such as the presence of attention-deficit hyperactivity disorder (ADHD) (Brandt & Fischer, 2019). Various hypotheses have been suggested to explain the mechanisms linking ADHD (particularly when it persists in adulthood) with GD (Jacob, Haro, & Koyanagi, 2018), high impulsivity levels being one of the core features (Abouzari, Oberg, Gruber, & Tata, 2015). It has also been postulated that children with ADHD usually report lower intelligence quotient (IQ) than control subjects (Biederman, Fried, Petty, Mahoney, & Faraone, 2012), and the combination of high impulsivity levels with lower IQ could lead to a higher risk of GD (Rai et al., 2014). Moreover, the presence of ADHD during childhood has been defined as a risk of personality disorders (such as borderline, antisocial, avoidant or narcissistic personality) and other psychiatric conditions (the most frequent being anxiety/mood disorders and substance-use disorders), which could play an important role in ADHD, impulsivity and problem gambling (Fatseas et al., 2016). Finally, typical ADHD symptoms have been related to the characteristic cognitive impairments of problem gambling (Chamberlain, Derbyshire, Leppink, & Grant, 2015).

Furthermore, high levels of decision-making impulsivity (largely motor inhibition, attention inhibition or decision-making tasks) have been related to the onset and progression of the GD (Ioannidis et al., 2019). Positive connections between probability discounting (a cognitive bias defined as the subjects' tendency to overvalue reinforcement with lower odds) and gambling have also been reported in the scientific

literature in recent years (Kyonka & Schutte, 2018; Steward et al., 2017). As regards the models of impulsivity used to assess the relationships between personality traits and problem gambling, one of the most widely used in the research area nowadays is the UPPS-P scale (Canale, Vieno, Bowden-Jones, & Billieux, 2017), originally based on a multi-faceted conception comprising five impulsive personality traits: lack of premeditation, lack of perseverance, sensation seeking, positive urgency, and negative urgency (Whiteside & Lynam, 2001). This scale was defined based on exploratory factor analysis to identify the personality facets associated with impulsive behaviors from among several other commonly used measurements of impulsivity, and it has shown to have robust correlation with different forms of psychopathology. But despite the extensive literature on GD and its relations to impulsivity, few studies have explored the contribution of chronological age to these associations. The available empirical data show complex underpinnings (Ioannidis et al., 2019; Mitchell & Potenza, 2014). While early impulsivity levels have been proven to increase the risk of impairing gambling behaviors in later life (Dussault et al., 2011), it also seems that regardless of age range gambling activity induces impulsivity levels that evolve into compulsion, chronic forms of addiction and more severe gambling behavior (Hodgins & Holub, 2015; Kovács et al., 2020). This scenario accentuates the need for new research with a special focus on the mechanisms underlying the multidimensional components of impulsivity and age in the GD area.

### Consideration of the preferred forms of gambling in the etiology of the GD

Finally, there is currently great interest in the study of preferred forms of gambling. Although most studies published to date have a preference-blind research approach, empirical research suggest that the gambling subtypes could provide an insight into the etiology and treatment of GD, and that taking the specific preferred gambling activity into account could be constraining individuals' phenotype (even about the gambling-related harm) and might offer information about treatment response and disease course (Stevens & Young, 2010; Subramaniam et al., 2016). Two broad categories have been proposed for grouping gambling activity based on the role of chance in the outcome of the game (Odlaug, Marsh, Kim, & Grant, 2011): non-strategic games (also called chance-based games, since little [or no] decision making or skill can be used by gamblers in determining the outcome; e.g., lotteries, slots-machines, bingo) versus strategic games (also called skill-based games, since autonomous decision making skills can be by used by gamblers in determining the outcome; e.g., poker, sports/animals betting, craps, stock market). The study of the correlates of the gambling preference have found multiple reasons that lead individuals to a preferred gambling style, including socio-demographics (gender, age, education level, civil status and social position (Jiménez-Murcia et al., 2019; Kastirke, Rumpf, John, Bischof, & Meyer, 2015), accessibility/availability of the gambling platforms (Moore, Thomas, Kyrios,



Bates, & Meredyth, 2011), certain personality traits (mainly novelty/sensation seeking and impulsivity levels) (Lorains, Stout, Bradshaw, Dowling, & Enticott, 2014b; Navas et al., 2017), and even the psychological state and level of the disordered gambling (Bonnaire et al., 2017; Chamberlain, Stochl, Redden, Odlaug, & Grant, 2017; Ledgerwood & Petry, 2010; Suomi, Dowling, & Jackson, 2014). Regarding the effect of chronological age on the gambling preference, chance-based games are more likelihood selected by older individuals, who tend to select low skill (high chance) gambling activities (Moragas et al., 2015). It has been suggested that age-related vulnerabilities of the brain typical among elderly (in particular the poor neuropsychological performance, which means reasoning slowness, difficulty to gain explicit insight into the rules of decision tasks, and limited ability in assess the real risks in decision making activities), could be a reason why elders select games characterized by lower decision making processes (Mouneyrac et al., 2018; Schiebener & Brand, 2017). On the other hand, lower age, higher levels in different impulsivity domains, and better cognitive performance, have been related to the preference for skill-based games (Jiménez-Murcia, Granero, Fernández-Aranda, & Menchón, 2020). And despite gambling preferences appearing to be relevant to the study of GD phenotypes and evidence existing of variables that may favor a preferred style of gambling, the underlying processes considering simultaneously cognitive biases, impulsivity levels, and chronological age are unknown.

## Objectives

In summary, empirical evidence support that cognitive biases and impulsivity levels play a relevant role for both the development and progression of the GD, and it seems that these constructs could be meaningfully interrelated. Studies also suggest that gambling preference may be clinically significant and could contribute towards the phenotype of GD patients. However, few studies have explored how patients' age can modulate the underlying mechanism between this set of variables during the adulthood, and to our knowledge no research has analyzed mediational links through path analysis.

The aim of this study was to assess the role of the aging process in the relationships between impulsivity profile and cognitive bias with gambling preferences and severity. The specific objectives were: a) to explore polynomial trends between patients' chronological age with impulsivity and cognitive distortions; and b) to assess the underlying mechanisms through path analysis (including mediational links) between the study variables: age, impulsivity profile, cognitive biases and gambling severity levels. Analyses were performed in a clinical sample of patients with ages between 18 to 77 years-old treatment seeking due the problematic gambling. Based on the empirical evidence we hypothesized: a) positive linear trends between age and impulsivity and cognitive bias levels; b) positive correlations between cognitive distortions and impulsivity levels; c) a mediational link between age, cognition and impulsivity measures, and gambling severity measures.

## METHODS

### Participants

The data analyzed in this work correspond to a research project developed at the Pathological Gambling Outpatient Unit at University Hospital of Bellvitge, with the objective to examine risk factors for gambling behavior in the adulthood population of individuals with gambling behavior. The initial sample considered for the study included  $n = 227$  patients recruited between July 2016 and October 2016, when they first attended for assessment and before starting treatment. Inclusion criteria in the study were age 18+ years-old, met clinical criteria for GD and education level and cognitive capacity to complete the self-report measurements of the study. Only patients who sought treatment for GD as their primary health concern were admitted to this study.

After accepting to be part of the study and completing the whole assessment, 16 women were excluded, due to the low frequency of this gender in the study and the difference in the age distribution between sexes (in the range 18–77 for men and 37–65 for women). Another two participants were not included in the analysis due to lack of response to the questionnaire measuring cognitive biases. Therefore, the final sample for the study was  $n = 209$  patients.

Three groups of age were defined in the study based on the tertiles in the study, with the aim to divide the sample in three parts each containing approximately a third of the participants (3 groups were considered to guarantee sample size enough for the statistical comparison and the remaining analyses). The three groups were labeled in this work as “younger age” (18–35 years,  $n = 73$ ), “middle age” (36–45 years,  $n = 63$ ), and “older age” (46–77 years,  $n = 73$ ). All the data analyzed in this work correspond to the first assessment before the patients began the therapy.

### Measures

*Diagnostic Questionnaire for Pathological Gambling (according to DSM criteria)* (Stinchfield, 2003). This is a self-report questionnaire including 19 items coded in a binary scale (yes-no), originally developed for diagnosing GD according to the DSM-IV-TR (American Psychiatric Association, 2010). This tool has currently been adapted to assess the DSM-5 criteria for GD (American Psychiatric Association, 2013) by deleting the illegal acts symptom and fixing a cut-off of four symptoms to diagnose GD (five was the cut-off for the DSM-IV-TR criteria). This self-report can obtain different measurements for the GD based on the DSM-5 taxonomy: the presence/absence for each DSM criterion, the presence/absence diagnosis for GD, a dimensional measurement of the gambling severity (total number of DSM criteria, obtained as the sum for the individual criteria), and the GD severity grouped in four levels [non-problematic gambling (for individuals who met 0 criteria), problematic gambling (for 1–3 criteria), moderate-GD (for 4–5 criteria), mild-GD (for 6–7 criteria), and severe-GD (for 8–9





criteria)]. The Spanish adaptation of the questionnaire used in this work obtained very good psychometrical properties (Cronbach's alpha equal to  $\alpha = 0.81$  for general population and  $\alpha = 0.77$  for clinical sample) (Jiménez-Murcia et al., 2009). The internal consistency obtained in the sample of this work was adequate ( $\alpha = 0.76$ ).

*South Oaks Gambling Severity Screen (SOGS)* (Lesieur & Blume, 1987). This is a 20-item self-report questionnaire developed with the aim of measuring the symptom level of the problem gambling, as well as the related negative consequences. A total score is generated as the sum of the items, typically considered as a measurement of the GD severity. Good psychometrical properties were obtained for the tool in different clinical and population-based settings (Lesieur & Blume, 1993), as well as for the Spanish validation used in this work (test-retest reliability  $R = 0.98$ , internal consistency  $\alpha = 0.94$  and convergent validity  $R = 0.92$ ) (Echeburúa, Báez, Fernández, & Páez, 1994). The internal consistency in the study was  $\alpha = 0.712$ .

*Gambling Related Cognitions Scale (GRCS)* (Raylu & Oei, 2004). This is a 23-item self-report questionnaire used to assess gambling-related cognitions in both population-based and clinical disordered gambling samples. Items are structured into five primary cognitive factors: gambling related expectancies, illusion of control, predictive control, perceived inability to stop gambling, and interpretative bias. A total score is also available as the sum of the primary-factor scores. The internal consistency in the study was  $\alpha = 0.76$  for expectancies,  $\alpha = 0.78$  for illusion of control,  $\alpha = 0.77$  for predictive control,  $\alpha = 0.81$  for illusion of control,  $\alpha = 0.78$  inability to stop gambling, and  $\alpha = 0.93$  for the total scale.

*Impulsive Behavior Scale (UPPS-P)* (Whiteside, Lynam, Miller, & Reynolds, 2005). This is a 59-item self-report questionnaire developed to assess different domains of impulsivity: lack of perseverance, lack of premeditation, sensation seeking, negative urgency, and positive urgency. This tool has obtained satisfactory psychometric properties in the original version and in the Spanish adaptation (Verdejo-García, Lozano, Moya, Alcazar, & Perez-García, 2010). The internal consistency in the study was  $\alpha = 0.75$  for lack of premeditation,  $\alpha = 0.82$  for lack of perseverance,  $\alpha = 0.85$  for sensation seeking,  $\alpha = 0.94$  for positive urgency, and  $\alpha = 0.87$  for negative urgency.

*Other variables.* The other variables analyzed in this study were assessed face-to-face with a semi-structured interview, which included socio-demographics (e.g. gender, education, civil status, and employment status), and other gambling problem related variables (age of onset and duration of the gambling behaviors, cumulate debts due to the gambling behaviors, and bets per gambling/episode). This specific tool has been described elsewhere (Jiménez-Murcia, Aymamí, Gómez-Peña, Álvarez-Moya, & Vallejo, 2006). Socioeconomic status was measured with the questionnaire designed by Hollingshead, which generates a position level index based on the education attainment and occupational prestige (Hollingshead, 2011).

## Statistical analysis

Statistical analysis was carried out with Stata16 for windows (Stata-Corp, 2019). Firstly, the association between patients' age and cognitive biases (GRCS scales) and impulsivity levels (UPPS-P scales) was estimated with Pearson correlation coefficients ( $R$ , also called the Pearson product-moment correlation coefficient). The Curve Estimation Fit procedure (CurveFit) was also used to test goodness-of-fit for functions different to the linear-model (logarithmic, inverse, quadratic, cubic, power, S, growth, exponential and logistic). The resulting non-adequate fit for most of the relationships suggested that a better understanding of the associations between the variables should be provided, categorizing age. Since there is no consensus regarding the bounds for age ranges within the gambling area (bounds substantially vary between studies according to different definitions and criteria), we decided on a classification in three groups based on the tertiles estimated in the sample itself, in this study labeled younger, middle and older age.

Secondly, the comparison of the means registered for the cognitive biases (GRCS scales) and the impulsivity levels (UPPS-P scales) between the age groups (younger, middle, and older) was based on analysis of variance (ANOVA), which included orthogonal polynomial contrasts to assess linear and quadratic trends and post-hoc multiple comparisons with the least significant difference estimation method. For this set of statistical comparisons, Finner's method (a familywise error rate procedure which is more powerful than the classical Bonferroni correction) was used to control increase in Type-I error due to multiple statistical tests (Finner, 1993). The effect size for the mean differences was also measured using Cohen's- $d$  (effect size was considered low-poor  $|d| > 0.20$ , moderate-medium for  $|d| > 0.5$ , and large-high for  $|d| > 0.8$ ) (Kelley & Preacher, 2012).

The association between the clinical profiles in the study (cognitive biases, impulsivity and other gambling related variables measured) were estimated with Pearson correlations ( $R$ ), stratified by the age groups. Due to the strong association between the statistical significance of  $R$ -coefficients and the sample size, the correlation effect sizes were established as follow: poor-low  $|R| > 0.10$ , moderate-medium  $|R| > 0.24$ , and large-high  $|R| > 0.37$  (these cut offs corresponded to a Cohen's- $d$  of 0.20, 0.50 and 0.80, respectively) (Rosnow & Rosenthal, 1996). Path analysis assessed the magnitude and significance of the relationships between the variables of the study with the gambling severity level, including direct and indirect effects (mediational links). This procedure can be used for both exploratory and confirmatory modeling, and therefore permits theory testing and theory development (MacCallum & Austin, 2000). This analysis was implemented as a case of structural equation modeling (SEM), using the maximum-likelihood estimation (MLE) method of parameter estimation (Kline, 2005). A latent variable was defined as a measure of the impulsivity levels defined by the UPPS-P scores. Goodness-of-fit was evaluated using standard statistical measures: chi-square test ( $\chi^2$ ), the root mean square error of approximation (RMSEA), Bentler's Comparative Fit Index (CFI), the



Tucker-Lewis Index (TLI), and the standardized root mean square residual (SRMR). Adequate model fit was considered for the following criteria (Barrett, 2007): RMSEA < 0.08, TLI > 0.9, CFI > 0.9, and SRMR < 0.1. The global predictive capacity of the model was measured by the coefficient of determination (CD). The variables used in the study as a measurement of the GD severity were the SOGS-total (as indicators of the GD symptom level) and the bets per gambling-episode (other alternative measures were not considered due the lack of fit).

## Ethics

Written informed consent was obtained for all the participants in the study. The work was approved by the Ethics

Committee of University Hospital of Bellvitge (reference number PR095/16) in accordance with the Helsinki Declaration of 1975 as revised in 1983.

## RESULTS

### Characteristics of the participants

The first block of Table 1 contains the descriptive parameters for the sociodemographics registered in the sample. Most participants were single (41.1%) or lived with a stable partner (46.9%), achieved primary (61.7%) or secondary education levels (30.1%), and had a low social index status (64.1%). The only differences that emerged between age

Table 1. Descriptive for the sample

		Total		Age 18–35		Age 36–45		Age 46–77		
		(n = 209)		(n = 73)		(n = 63)		(n = 73)		
<i>Sociodemographics</i>		<i>n</i>	<i>%</i>	<i>n</i>	<i>%</i>	<i>n</i>	<i>%</i>	<i>n</i>	<i>%</i>	<i>p</i>
Marital status	Single	86	41.1%	48	65.8%	26	41.3%	12	16.4%	<0.001*
	Married	98	46.9%	22	30.1%	28	44.4%	48	65.8%	
	Divorced	25	12.0%	3	4.1%	9	14.3%	13	17.8%	
Education	Primary	129	61.7%	43	58.9%	35	55.6%	51	69.9%	0.319
	Secondary	63	30.1%	23	31.5%	24	38.1%	16	21.9%	
	University	17	8.1%	7	9.6%	4	6.3%	6	8.2%	
Social index	Mean-high to high	4	1.9%	0	0.0%	2	3.2%	2	2.7%	0.469
	Mean	20	9.6%	9	12.3%	6	9.5%	5	6.8%	
	Mean-low	51	24.4%	19	26.0%	18	28.6%	14	19.2%	
	Low	134	64.1%	45	61.6%	37	58.7%	52	71.2%	
Employment	Unemployed	67	32.1%	24	32.9%	14	22.2%	29	39.7%	0.091
	Employed	142	67.9%	49	67.1%	49	77.8%	44	60.3%	
<i>Substances use-abuse</i>		<i>n</i>	<i>%</i>	<i>n</i>	<i>%</i>	<i>n</i>	<i>%</i>	<i>n</i>	<i>%</i>	<i>p</i>
Tobacco		112	53.6%	41	56.2%	38	60.3%	33	45.2%	0.182
Alcohol		54	25.8%	15	20.5%	19	30.2%	20	27.4%	0.412
Other illegal drugs		22	10.5%	6	8.2%	9	14.3%	7	9.6%	0.490
<i>Prevalence of comorbid disorders</i>		<i>n</i>	<i>%</i>	<i>n</i>	<i>%</i>	<i>n</i>	<i>%</i>	<i>n</i>	<i>%</i>	<i>p</i>
<sup>a</sup> Any other comorbid disorder		62	29.7%	17	23.3%	23	36.5%	22	30.1%	0.241
Depression		14	6.7%	2	2.7%	4	6.3%	8	11.0%	0.138
Anxiety		20	9.6%	3	4.1%	5	7.9%	12	16.4%	0.035*
Specific Phobic		1	0.5%	0	0.0%	1	1.6%	0	0.0%	0.312
Social Phobia		1	0.5%	0	0.0%	0	0.0%	1	1.4%	0.392
Compulsive-essive		7	3.3%	1	1.4%	1	1.6%	5	6.8%	0.119
Other		20	9.6%	7	9.6%	7	11.1%	6	8.2%	0.849
<i>Gambling variables</i>		<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>	<i>Mean</i>	<i>SD</i>	<i>p</i>
Chronological age (years-old)		41.97	13.38	27.94	5.28	40.91	2.84	56.93	7.43	<0.001*
Age of onset (years-old)		25.62	10.31	20.62	4.37	24.93	8.86	31.22	12.76	<0.001*
Duration of gambling (years)		16.35	12.57	7.32	5.21	15.98	9.39	25.71	13.50	<0.001*
DSM-5 total criteria		7.19	1.64	7.12	1.48	7.25	1.67	7.19	1.78	0.899
SOGS total score		14.56	4.29	14.29	4.64	14.90	4.08	14.53	4.15	0.706
Debts due to gambling		4,125	5,636	4,019	5,417	3,786	5,503	4,525	6,006	0.735
Bets mean/episode		67	85	66	81	83	98	54	73	0.131
Bets maximum/episode		587	636	621	637	638	670	508	605	0.417
<i>Gambling preference</i>		<i>n</i>	<i>%</i>	<i>n</i>	<i>%</i>	<i>n</i>	<i>%</i>	<i>n</i>	<i>%</i>	<i>p</i>
Non-strategic		149	71.3%	46	63.0%	42	66.7%	61	83.6%	0.014*
Strategic		60	28.7%	27	37.0%	21	33.3%	12	16.4%	

Note. SD: standard deviation. \*Bold: significant comparison (0.05).

<sup>a</sup>This variable has been generated to identify the presence of at least one comorbid disorder.



groups was in the civil status (the prevalence of single participants was higher among younger age).

The second and third block of Table 1 contains the prevalence of substances use-abuse and the presence of other comorbid disorders. No differences between groups were found, except for the prevalence of anxiety disorder which showed a higher frequency in older participants.

As regards gambling variables, age of onset was lower with the lower the age of the patients, while duration was higher with the older the age. No differences were found between the groups for the variables measuring the gambling severity (gambling symptoms level, debts due to gambling, and bets per gambling-episode). Differences between the groups also were found for the gambling preferred subtype, with the prevalence for strategic games being most frequent in younger patients.

### Association between age with cognitive biases and impulsivity levels

Table S1 (supplementary material) contains the Pearson correlation coefficients and the results of the CurveFit procedure measuring the linear and non-linear functions between chronological age (considered on a continuous scale, in years of age) with the GRCS and UPPS-P scales. No relevant correlation emerged (all coefficients were in the poor-low range) and non-significant results were also obtained for most of the models tested (except for inability to stop gambling [ $F = 3.76$ ,  $df = 3/205$ ,  $P = 0.012$ ] and sensation seeking [ $P < 0.005$ ] for many of the polynomial contrasts).

Table 2 shows the mean scores in the GRCS and UPPS-P scales (see also mean plots in Fig. 1 and radar-chart in

Fig. 2), as well as the results of the ANOVA comparing the groups of age (younger, middle and older). As regards the cognitive bias severity, a quadratic trend was found for the predictive control, interpretative bias and the total score (line plots in Fig. 1 seem to be similar polynomial functions to curved parabolas): younger and older groups showed the highest means, while middle-age group showed the lowest mean. A positive linear trend was obtained for the perceived inability to stop gambling: as the higher the age the higher was the mean level in the scale. Considering the impulsivity levels, No differences between the groups of age were found in the impulsivity levels, except for the sensation seeking scale, which showed a negative linear trend: the older the age the lower was the mean score in this scale.

### Contribution of the age on the associations between cognitive and impulsivity with gambling

Table 3 contains the correlation matrix with the variables measuring cognitive bias, impulsivity levels and gambling severity, stratified by the groups of age. Italic font is used for the correlations obtained between scales of the same questionnaire or construct (which tended to be relevant in the three groups of the study, excepting for the association between the GD severity measures). As a whole, the pattern of relationships was different depending on the participants' age. Among younger age patients: a) cognitive bias severity tended to show positive associations with the impulsivity levels (mainly with the positive and negative urgency scales); b) higher level in cognitive bias (except for gambling related expectancies and illusion of control) positively correlated with the GD symptom level and the cumulate debts due to the gambling activity; and c) the impulsivity levels did not

Table 2. Differences between groups of age on the cognitive biases related to gambling and impulsivity levels

	Age 18–35		Age 36–45		Age 46–77		Polynomial		Pairwise comparisons					
	Y-Young		M-Middle		O-Old		Trends		(post-hoc contrasts)					
	(n = 73)		(n = 63)		(n = 73)		LT	QT	Y vs. M		Y vs. O		M vs. O	
	Mean	SD	Mean	SD	Mean	SD	p	p	p	d	p	d	p	d
<b>Cognitive bias (GRCS)</b>														
Expectancies	12.38	7.20	11.00	7.31	12.40	7.64	0.991	0.213	0.278	0.19	0.991	0.00	0.273	0.19
Illusion of control	7.89	4.80	6.89	4.77	8.55	6.16	0.455	0.098	0.274	0.21	0.455	0.12	0.070	0.30
Predictive control	17.29	8.68	13.89	7.28	17.64	8.82	0.796	<b>0.005*</b>	<b>0.019*</b>	0.42	0.796	0.04	<b>0.009*</b>	0.46
Inability stop gambling	15.78	7.71	16.52	7.77	19.07	9.25	<b>0.018*</b>	0.472	0.603	0.10	<b>0.018*</b>	0.39	0.076	0.30
Interpretive bias	13.51	7.22	11.78	6.53	14.38	7.38	0.455	<b>0.043*</b>	0.157	0.25	0.455	0.12	<b>0.033*</b>	0.37
Total score	66.85	30.12	60.11	27.18	71.99	31.59	0.299	<b>0.040*</b>	0.190	0.23	0.299	0.17	<b>0.021*</b>	0.40
<b>Impulsivity (UPPS-P)</b>														
Lack of premeditation	24.01	7.42	24.59	6.97	24.67	8.37	0.604	0.832	0.663	0.08	0.604	0.08	0.949	0.01
Lack of perseverance	21.49	5.61	22.62	5.19	22.18	6.95	0.491	0.387	0.277	0.21	0.491	0.11	0.670	0.07
Sensation seeking	29.21	7.53	26.03	8.87	25.42	8.17	<b>0.006*</b>	0.299	<b>0.025*</b>	0.39	<b>0.006*</b>	<b>0.51†</b>	0.666	0.07
Positive urgency	31.16	10.95	31.25	11.01	31.70	11.56	0.773	0.916	0.963	0.01	0.773	0.05	0.817	0.04
Negative urgency	31.21	8.35	32.38	7.71	32.75	8.11	0.248	0.742	0.398	0.15	0.248	0.19	0.789	0.05

Note. SD: standard deviation. LT: linear trend. QT: quadratic trend.

\*Bold: significant comparison (0.05). †Bold: effect size into the mean-moderate ( $|d| > 0.50$ ) to high-large ( $|d| > 0.80$ ) range.



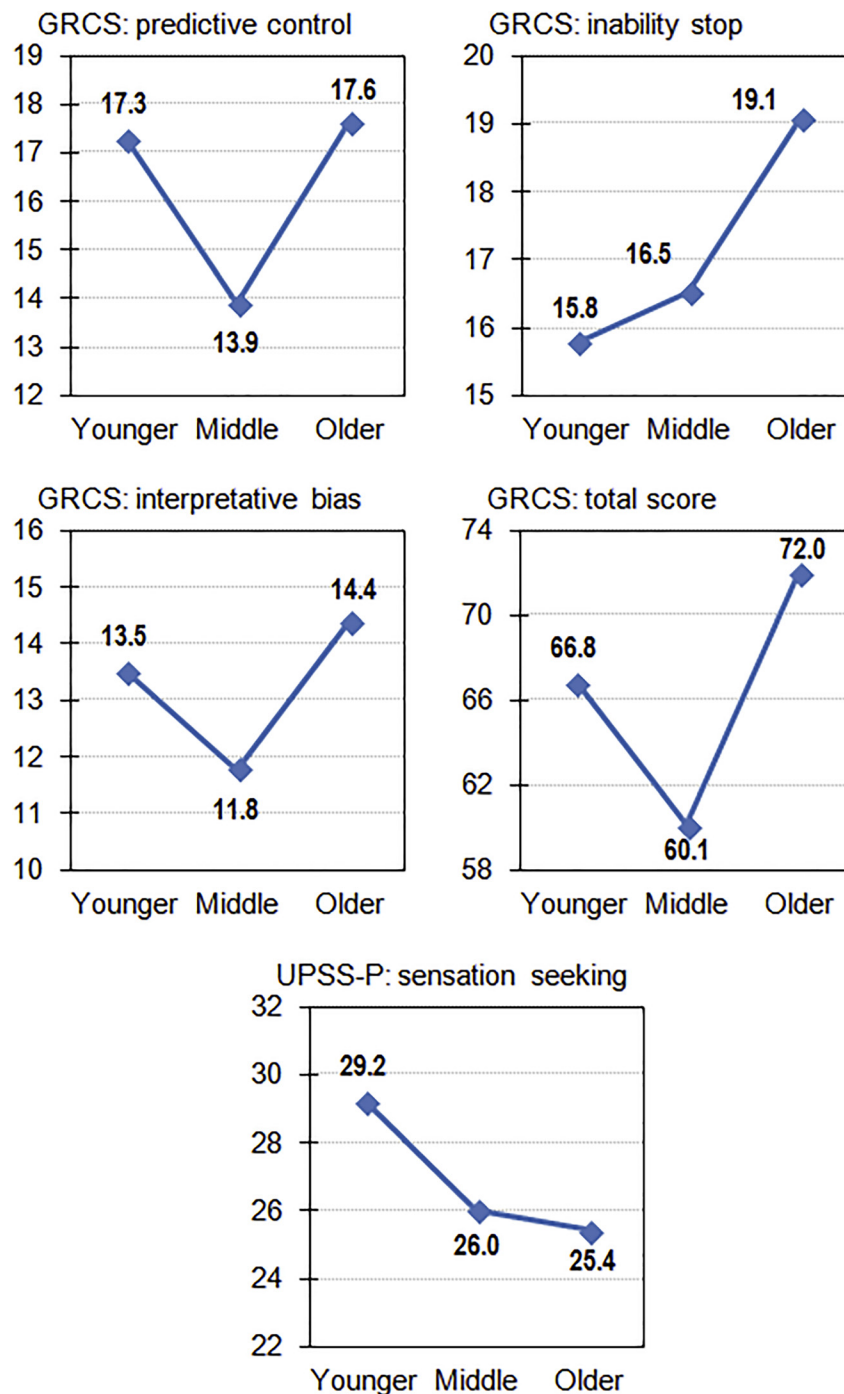


Fig. 1. Mean plots ( $n = 209$ )

relate to the gambling severity. Among older age patients: a) cognitive bias also tended to correlate with impulsivity levels (especially with lack of premeditation and lack of perseverance scales); b) regarding cognitive bias severity, gambling-related expectancies correlated with the debts due to the gambling activity, while inability to stop gambling correlated with the bets per gambling/episode; c) lack of premeditation and lack of perseverance related to the cumulate debts due to gambling, and negative urgency correlated with the bets per gambling-episode; and d) no association was found between

the GD symptom level with cognitive bias or impulsivity levels. And among middle age patients: a) a few number of associations emerged between cognitive bias severity and impulsivity levels (and effect size was also lower than correlations obtained in the other two groups); b) GD symptom levels correlated with both cognitive bias severity and impulsivity levels (except for lack of premeditation and lack of perseverance); c) the bets per gambling-episode correlated with the cognitive bias severity in the predictive of control, interpretative bias and total score.



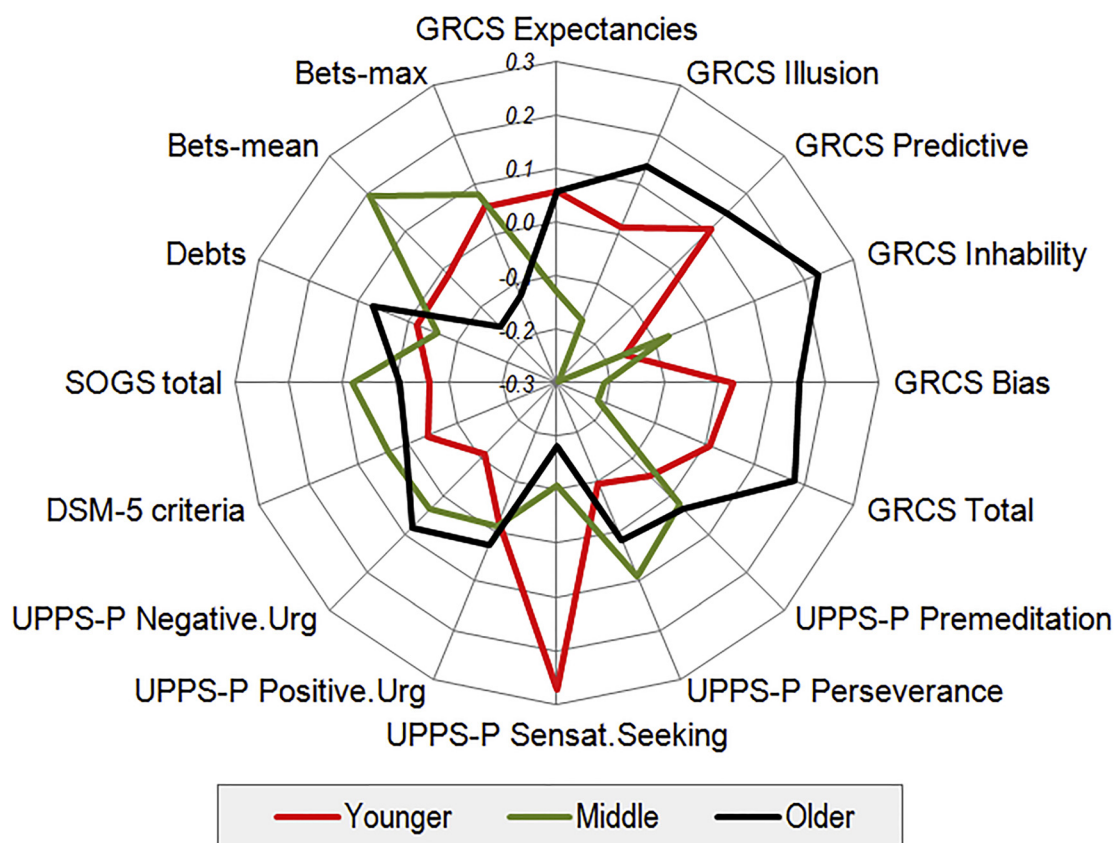


Fig. 2. Radar-chart with the z-standardized means based on the groups of age ( $n = 209$ )

### Path analysis

Figure 3 contains the path-diagram with the standardized coefficients obtained in the SEM. This model included the participants' age (defined as a continuous variable, in years of age), impulsivity level (a latent variable defined by the UPPS-P scores), global cognitive bias level, gambling related variables (preferred subtype and measures of severity), and the variables that had achieved a significant relationship with the patients' age (marital status, comorbidity with psychiatric disorders and duration of the gambling behavior). Age of onset was not considered a predictor or a potential confounding variable in the SEM since it is generated as the difference between chronological age and the duration of the problematic gambling, with the consequence of lack of fit due to the collinearity among predictors.

Only significant parameters were retained in the model, which was adjusted for the GD duration. The latent variable defining the impulsivity levels was positively and significantly defined by all the UPPS-P scales. Adequate goodness-of-fit was obtained:  $\chi^2 = 71.39$  ( $P = 0.171$ ), RMSEA = 0.029 (95% CI: 0.001–0.053), CFI = 0.980, TLI = 0.972 and SRMR = 0.046. The global predictive capacity was  $CD = 0.726$ . The results of the SEM indicate that higher impulsivity levels directly explained the cumulate debts due to the gambling activity. Higher cognitive bias severity showed a direct effect increasing the likelihood of strategic gambling preference, higher GD symptom level, and higher

bets per gambling-episode. Age also contributed in the gambling profile: a) a direct effect related younger ages with strategic gambling preference; b) a mediational link related older age with higher likelihood of a comorbid depression-anxiety disorder, which presence increased the GD symptom level. Civil status also contributed in the model: being unmarried (single, divorced-separated or widowed) increased the bets per gambling episode, as well as in the mediational link of increasing the likelihood of comorbidity with depression-anxiety and therefore the GD symptom severity.

### DISCUSSION

This study assessed the role of chronological age in the underlying mechanism between cognitive biases, impulsivity levels, and preferred forms of gambling with the GD severity measures. The results obtained evidenced a higher impairing cognitive functioning among younger and older patients, while similar impulsivity levels were achieved by the different age groups (except for sensation seeking, with higher scores among younger ages). Moreover, path analysis showed a direct contribution of cognitive bias to strategic gambling preference, GD symptom level and bets per gambling-episode, a direct effect of impulsivity levels on debts due to the gambling activity, a negative direct effect of age on gambling preference, and a mediational link between



Table 3. Association between cognitive biases with impulsivity and gambling severity: Pearson correlation coefficients

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
<i>Age: 18–35 (n = 73)</i>															
1. GRCS Expectancies	<b>0.48<sup>†</sup></b>	<b>0.66<sup>†</sup></b>	<b>0.70<sup>†</sup></b>	<b>0.64<sup>†</sup></b>	<b>0.84<sup>†</sup></b>	<b>0.32<sup>†</sup></b>	<b>0.36<sup>†</sup></b>	0.15	<b>0.32<sup>†</sup></b>	<b>0.34<sup>†</sup></b>	0.07	0.16	0.12	0.16	0.15
2. GRCS Illusion of control	–	<b>0.65<sup>†</sup></b>	<b>0.49<sup>†</sup></b>	<b>0.54<sup>†</sup></b>	<b>0.72<sup>†</sup></b>	<b>0.33<sup>†</sup></b>	0.22	0.13	<b>0.35<sup>†</sup></b>	<b>0.30<sup>†</sup></b>	0.16	0.15	0.08	0.11	0.15
3. GRCS Predictive control		–	<b>0.68<sup>†</sup></b>	<b>0.75<sup>†</sup></b>	<b>0.90<sup>†</sup></b>	0.09	<b>0.24<sup>†</sup></b>	0.05	<b>0.24<sup>†</sup></b>	<b>0.28<sup>†</sup></b>	0.16	0.22	<b>0.26<sup>†</sup></b>	0.12	0.08
4. GRCS Inability stop			–	<b>0.67<sup>†</sup></b>	<b>0.86<sup>†</sup></b>	0.14	<b>0.34<sup>†</sup></b>	0.17	<b>0.39<sup>†</sup></b>	<b>0.38<sup>†</sup></b>	0.22	<b>0.29<sup>†</sup></b>	0.09	0.12	0.13
5. GRCS Interpretive bias				–	<b>0.86<sup>†</sup></b>	<b>0.24<sup>†</sup></b>	0.17	0.06	<b>0.35<sup>†</sup></b>	<b>0.41<sup>†</sup></b>	<b>0.28<sup>†</sup></b>	<b>0.27<sup>†</sup></b>	<b>0.25<sup>†</sup></b>	0.12	0.19
6. GRCS Total score					–	<b>0.25<sup>†</sup></b>	<b>0.32<sup>†</sup></b>	0.13	<b>0.39<sup>†</sup></b>	<b>0.41<sup>†</sup></b>	0.21	<b>0.27<sup>†</sup></b>	0.20	0.15	0.16
7. UPPS-P Premeditation						–	<b>0.52<sup>†</sup></b>	0.05	<b>0.39<sup>†</sup></b>	<b>0.42<sup>†</sup></b>	0.15	–0.06	–0.02	–0.08	0.06
8. UPPS-P Perseverance							–	–0.01	<b>0.35<sup>†</sup></b>	<b>0.34<sup>†</sup></b>	0.12	0.10	0.03	–0.12	–0.18
9. UPPS-P Sens. seeking								–	<b>0.45<sup>†</sup></b>	<b>0.39<sup>†</sup></b>	0.05	–0.05	–0.11	–0.15	–0.12
10. UPPS-P Posit. urgency									–	<b>0.85<sup>†</sup></b>	0.20	0.20	–0.02	0.00	0.02
11. UPPS-P Negat. urgency										–	0.13	0.13	–0.04	0.01	–0.08
12. DSM-5 criteria for GD											–	<b>0.41<sup>†</sup></b>	–0.06	0.09	0.08
13. SOGS total score												–	0.08	0.10	0.01
14. Debts due to gambling													–	<b>0.37<sup>†</sup></b>	<b>0.36<sup>†</sup></b>
15. Bets mean/episode														–	<b>0.50<sup>†</sup></b>
16. Bets max/episode															–
<i>Age: 36–45 (n = 63)</i>															
1. GRCS Expectancies	<b>0.52<sup>†</sup></b>	<b>0.73<sup>†</sup></b>	<b>0.48<sup>†</sup></b>	<b>0.67<sup>†</sup></b>	<b>0.86<sup>†</sup></b>	<b>0.26<sup>†</sup></b>	0.18	0.19	0.22	0.14	<b>0.42<sup>†</sup></b>	0.17	0.18	–0.11	0.11
2. GRCS Illusion of control	–	<b>0.49<sup>†</sup></b>	0.20	<b>0.56<sup>†</sup></b>	<b>0.63<sup>†</sup></b>	–0.03	0.08	0.03	0.16	0.14	<b>0.34<sup>†</sup></b>	0.00	0.20	–0.06	0.12
3. GRCS Predictive control		–	<b>0.54<sup>†</sup></b>	<b>0.74<sup>†</sup></b>	<b>0.89<sup>†</sup></b>	0.16	0.15	0.08	0.12	0.12	<b>0.37<sup>†</sup></b>	–0.09	0.10	0.09	<b>0.34<sup>†</sup></b>
4. GRCS Inability stop			–	<b>0.56<sup>†</sup></b>	<b>0.73<sup>†</sup></b>	<b>0.28<sup>†</sup></b>	<b>0.42<sup>†</sup></b>	0.19	0.17	<b>0.29<sup>†</sup></b>	<b>0.27<sup>†</sup></b>	0.02	0.14	0.00	0.11
5. GRCS Interpretive bias				–	<b>0.88<sup>†</sup></b>	0.16	<b>0.28<sup>†</sup></b>	0.15	0.18	<b>0.27<sup>†</sup></b>	<b>0.44<sup>†</sup></b>	0.06	0.19	0.05	<b>0.31<sup>†</sup></b>
6. GRCS Total score					–	0.23	<b>0.29<sup>†</sup></b>	0.17	0.21	<b>0.24<sup>†</sup></b>	<b>0.43<sup>†</sup></b>	0.04	0.19	0.00	<b>0.25<sup>†</sup></b>
7. UPPS-P Premeditation						–	<b>0.67<sup>†</sup></b>	0.22	0.21	<b>0.28<sup>†</sup></b>	0.07	–0.01	0.18	–0.09	–0.01
8. UPPS-P Perseverance							–	–0.02	<b>0.25<sup>†</sup></b>	<b>0.40<sup>†</sup></b>	0.04	–0.06	0.21	–0.22	0.03
9. UPPS-P Sens. seeking								–	<b>0.53<sup>†</sup></b>	<b>0.49<sup>†</sup></b>	<b>0.29<sup>†</sup></b>	–0.07	–0.20	0.06	0.06
10. UPPS-P Posit. urgency									–	<b>0.71<sup>†</sup></b>	<b>0.25<sup>†</sup></b>	0.00	0.07	–0.04	–0.07
11. UPPS-P Negat. urgency										–	<b>0.25<sup>†</sup></b>	–0.01	–0.10	0.00	0.07
12. DSM-5 criteria for GD											–	<b>0.26<sup>†</sup></b>	–0.04	–0.20	–0.06
13. SOGS total score												–	–0.09	–0.22	–0.36 <sup>†</sup>
14. Debts due to gambling													–	–0.04	0.04
15. Bets mean/episode														–	<b>0.35<sup>†</sup></b>
16. Bets max/episode															–
<i>Age: 46–77 (n = 73)</i>															
1. GRCS Expectancies	<b>0.60<sup>†</sup></b>	<b>0.64<sup>†</sup></b>	<b>0.41<sup>†</sup></b>	<b>0.59<sup>†</sup></b>	<b>0.79<sup>†</sup></b>	<b>0.43<sup>†</sup></b>	<b>0.48<sup>†</sup></b>	<b>0.35<sup>†</sup></b>	<b>0.33<sup>†</sup></b>	<b>0.27<sup>†</sup></b>	0.11	0.14	<b>0.24<sup>†</sup></b>	0.15	0.23
2. GRCS Illusion of control	–	<b>0.69<sup>†</sup></b>	<b>0.45<sup>†</sup></b>	<b>0.54<sup>†</sup></b>	<b>0.79<sup>†</sup></b>	0.22	<b>0.24<sup>†</sup></b>	0.19	0.12	0.11	0.17	0.04	0.13	0.09	0.08
3. GRCS Predictive control		–	<b>0.48<sup>†</sup></b>	<b>0.62<sup>†</sup></b>	<b>0.85<sup>†</sup></b>	<b>0.32<sup>†</sup></b>	<b>0.33<sup>†</sup></b>	0.22	0.17	0.14	0.04	0.10	0.03	0.04	0.11
4. GRCS Inability stop			–	<b>0.62<sup>†</sup></b>	<b>0.76<sup>†</sup></b>	<b>0.42<sup>†</sup></b>	<b>0.29<sup>†</sup></b>	0.18	0.18	<b>0.33<sup>†</sup></b>	0.07	0.00	–0.02	0.14	<b>0.28<sup>†</sup></b>
5. GRCS Interpretive bias				–	<b>0.84<sup>†</sup></b>	<b>0.30<sup>†</sup></b>	<b>0.31<sup>†</sup></b>	0.18	0.15	0.18	0.15	0.13	0.08	–0.02	0.06
6. GRCS Total score					–	<b>0.43<sup>†</sup></b>	<b>0.41<sup>†</sup></b>	<b>0.28<sup>†</sup></b>	<b>0.24<sup>†</sup></b>	<b>0.27<sup>†</sup></b>	0.13	0.10	0.10	0.10	0.20
7. UPPS-P Premeditation						–	<b>0.75<sup>†</sup></b>	<b>0.25<sup>†</sup></b>	<b>0.33<sup>†</sup></b>	<b>0.53<sup>†</sup></b>	0.07	0.03	<b>0.33<sup>†</sup></b>	0.19	0.23

(continued)

Table 3. Continued

	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
8. UPPS-P Perseverance								0.22	<b>0.31<sup>†</sup></b>	<b>0.45<sup>†</sup></b>	0.04	0.07	<b>0.31<sup>†</sup></b>	0.18	0.15
9. UPPS-P Sens. seeking							-	-	<b>0.51<sup>†</sup></b>	<b>0.34<sup>†</sup></b>	-0.06	-0.05	0.09	-0.03	0.21
10. UPPS-P Posit. urgency									-	<b>0.66<sup>†</sup></b>	0.07	-0.01	0.19	0.04	0.17
11. UPPS-P Negat. urgency										-	-0.09	0.06	0.21	<b>0.29<sup>†</sup></b>	0.23
12. DSM-5 criteria for GD											-	<b>0.36<sup>†</sup></b>	0.11	-0.02	-0.13
13. SOGS total score												-	-0.02	0.20	0.03
14. Debts due to gambling													-	<b>0.27<sup>†</sup></b>	0.23
15. Bets mean/episode														-	<b>0.54<sup>†</sup></b>
16. Bets max/episode															-

Note. <sup>†</sup>Bold: effect size into the mean-moderate ( $|R| > 0.24$ ) to high-large ( $|R| > 0.37$ ) range.

age and the presence of a comorbid depressive-anxiety disorder and GD symptom level.

The results obtained in this work showing the relationships between high impulsivity and strong cognitive biases with the gambling symptoms level are consistent with previous evidence reported in scientific literature (Del Prete et al., 2017; Michalczuk, Bowden-Jones, Verdejo-Garcia, & Clark, 2011; Ruiz de Lara, Navas, & Perales, 2019). It has been postulated that impulsivity behavior in decision making tasks could predispose individuals to accept erroneous beliefs without questioning in GD in at-risk (problem) gambling (Ioannidis et al., 2019). A recent meta-analysis has also demonstrated the existence of a synergistic relationship of different measures and components of impulsivity with cognitive distortions related to substance addictions (which seem independent of moderator influences), which could be compatible with incentive sensitization theory of addiction processes (Leung et al., 2017). Our results could suggest an expansion of this theory to the behavioral addictions area, particularly to explain the development course of the GD.

But still more relevant: in this study a quadratic trend has emerged between patient age and gambling related cognitive bias level, while there was no association between impulsivity levels and age, except for sensation seeking (which adjusted to a negative linear trend). These are novel findings, and seemingly contradictory to the evidence previously reported in literature. Neurocognitive studies have shown that age is a key factor for changes in negatively biased information-processing, and many studies in this area have thoroughly identified and described the sharp decline in several cognitive tasks performance with advancing age (Harada, Natelson Love, & Triebel, 2013). Based on these studies, cognitive abilities related to reasoning, memory, and processing performance decline gradually over time, which could make us hypothesized (at least) a positive linear trend between age and cognitive bias (and depending on the processing speed with which cognitive activities performed, also a quadratic trend describing the slowing/rapidity of the processes among the groups of age) (Salthouse, 2010). However, most of the published studies have been interpreted comparing cognitive bias profiles with standardized age-related trajectories in a typically developing population, which makes it difficult to compare this evidence with the results obtained in our sample (consisting exclusively of GD treatment-seeking patients). And although it is very important to find out what are the cognitive changes of individuals who met clinical criteria for a psychopathological condition compared to the normal process accompanying aging (to evaluate how these unhealthy processes affect daily functioning, and to identify structural and functional alterations in brain) (Salthouse, 2012), it is also of increasingly importance to understand the cognitive changes that accompany aging in samples with mental health conditions. This was a primary novel objective of this work, and our results are also pioneering in this area.

As regards the changes in impulsivity levels with age, a similar process can be considered: since it is 'normal' for

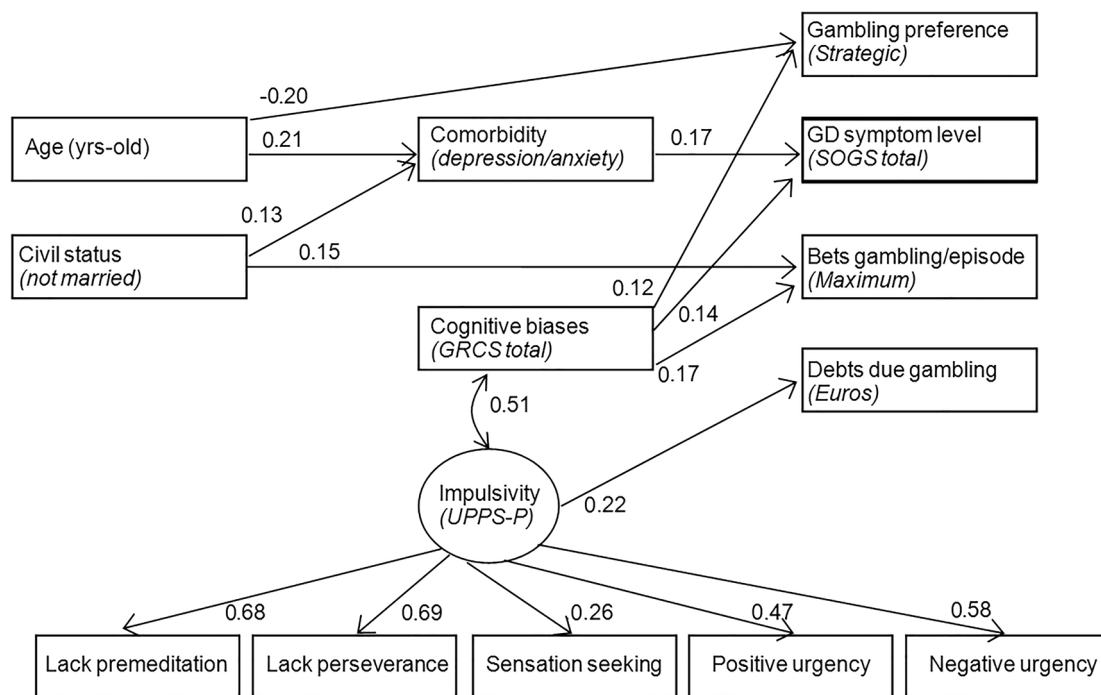


Fig. 3. Path-diagram with the results of the SEM ( $n = 209$ ). Note. Only significant coefficients were retained in the model. Results adjusted by the duration of the GD

impulsivity to decline as people grow older, we had hypothesized a decrease in the means for the UPPS-P scales when comparing younger, middle and older age. However, this pattern was only identified for one of the impulsivity components analyzed in the study: sensation seeking scale reported lower scores as the patient age increased. To understand this apparent discrepant result, it must be realized that our study analyzes a clinical sample of patients treatment-seeking for an addictive disorder (GD) that occurs throughout the life cycle, and that is characterized by a strong lifespan impulsivity-related pattern. It is therefore not surprising that impulsivity becomes decreasingly less frequent with aging among patients with problem gambling, and that poor impulsive control should be reported independent of the chronological age. This result outlines the relevance of impulsivity in all GD groups, including younger and older groups.

On the other hand, the pattern of associations between cognitive distortions and impulsivity with the gambling severity obtained in this work was moderated by patient age. Most studies evaluating the contribution of impulsivity and cognitive bias on the gambling related behaviors have obtained strong associations, independent of age. But again, most of these studies only measured these constructs at a single point-in-time, and therefore the links between the manifestation of impulsivity and cognitive performance in GD patients of different age groups was unclear. Our results outline that although impulsivity and cognitive bias should be (strongly) related with GD and problem/at-risk gambling, age seems to be moderating the frequency and effect size of these relationships. This evidence may have implications for

the development of reliable/valid assessment tools and effective therapeutic plans, which should consider the particular cognitive style and the impulsivity profiles expected within different age groups.

The results of the SEM in this study indicate that higher cognition bias is predictive of higher impairment due to the gambling activity, and it demonstrates the existence of a mediational link between age, depression-anxiety and the GD severity. A number of studies have reported that problem and disordered gambling showed higher cognitive distortions, and perceived experiencing higher levels of negative affective states than recreational gambling and control samples (Tang & Oei, 2011; Yang, Tang, Gu, Luo, & Luo, 2015). Studies have also reported that the poorer performance in decision-making tasks correlates with the higher gambling severity (Cosenza, Ciccirelli, & Nigro, 2019). Our study contributes in this area, since it shows that, although gambling severity might seem independent of the chronological age in clinical samples of GD treatment-seeking patients, a mediational/indirect effect is observed through the presence of a comorbid depressive-anxiety disorder: older subjects are particularly vulnerable to increase the gambling impairment if they have a comorbid mental problem. Moreover, according to the SEM obtained in this study sample, civil status was also a variable to be considered in this mechanism: being unmarried (single, divorced or widowed) not only shows a direct effect on the bets per gambling-episode, but also increases the risk of a comorbid depressive-anxiety problems and, therefore, is an indirect variable explaining the GD severity. This result is consistent with previous etiological studies focused on the



identification of the variables related with the onset of the GD and the severity of the gambling behaviors, which outline that having a stable partner is a preventive factor (Elton-Marshall et al., 2018). Furthermore, the global results of the SEM add the novel evidence that older age and being unmarried increase the odds of depressed-anxious problems, and that this is precisely a profile highly vulnerable to present with the most severe consequences of the GD. It must be noted that older adults usually experience financial difficulties or insecurity, loss of physical ability (particularly mobility), as well as a loss of relationships with relatives and friends. Furthermore, subjects are likely to lose their partner during later life, and since unpartnered older adults tend to be more socially isolated (with the consequence of increasing depression and anxiety levels), the risk of severe problematic gambling due to loneliness and its consequences is predictable (Botterill, Gill, McLaren, & Gomez, 2016; Parke, Griffiths, Pattinson, & Keatley, 2018).

Path analysis in this study showed a direct contribution of cognitive distortions level on the likelihood of strategic gambling preference, which is consistent with other previous empirical studies (Levésque, Sévigny, Giroux, & Jacques, 2017; Navas et al., 2017). However, our SEM did not retain a direct association between the impulsivity levels and the gambling subtype, as was suggested by previous studies that concluded that higher levels of impulsivity behavior may increase likelihood of strategic gambling, as well as a higher risk of accumulating losses (Lorains, Dowling, et al., 2014a; Lorains, Stout, et al., 2014b; Worhunsky, Potenza, & Rogers, 2017). It must be noted, however, that our study includes simultaneously the cognitive bias severity and the impulsivity levels in the path analysis, which allows obtaining the specific contribution of each construct on the gambling type. Indeed, the path in our work show a correlation between impulsivity and disturbed thoughts (higher impulsivity levels are related to worse cognitive reasoning performance), and therefore it would also be possible to consider both a direct effect of cognitive bias on the gambling preference, and also that cognitive style could act as a mediational variable in the relationship between the impulsivity levels and the preferred gambling style. On the other hand, considering that strategic gambling in the sample of this work was directly related to younger age, the results of the SEM seem consistent with a new phenotype described in the GD profile characterized by strong gambling-related cognitive distortions, young age, and the preference for skill-based games (Mallorquí-Bagué, Mestre-Bach et al., 2018a; Mallorquí-Bagué, Tolosa-Sola et al., 2018b; Myrseth, Brunborg, & Eidem, 2010; Perales, Navas, Ruiz de Lara, Maldonado, & Catena, 2017). Evidence published to date suggest that this phenotype may be explained by heightened sensitivity to the rewarding features of gambling activities, greater disinhibition and sensation seeking, and therefore, with a higher risk for progression and escalating the disordered gambling, and could be even related to the new forms of gambling activities (such as online gambling) (Jiménez-Murcia et al., 2019).

## Limitations, strengths and implications

Three main limitations should be taken into account when interpreting the results of this work. Firstly, because the patients in our sample are all men, extrapolation of the results to women is not possible. Secondly, the data analyzed are from a cross-sectional study, which does not allow the longitudinal changes in the measures to be determined (a repeated measures design should allow developmental trajectories of individual facets of cognitive bias and impulsivity to be examined, as well as its relationship with the GD profile). And thirdly, although a number of constructs strongly related to the GD severity and the gambling preference were analyzed in the study (age, cognitive biases, impulsivity, sociodemographic features and comorbid psychopathological state), other variables that could also be involved in the GD mechanism were not addressed.

Some strengths should also be noted. The sample of this study included patients from a large range of ages (between 18 to 77 years-old), and therefore results may be extrapolated to a substantial proportion of GD treatment-seeking patients. The multivariate analysis of two constructs strongly related to the GD (cognitive bias and age) is another relevant strength, since it allows obtaining the specific contribution of each domain in the gambling profile, as well as the potential moderator role of the patients' age.

This study has clinically relevant implications in the area of the development of assessment tools with high reliability to identify the core components of the GD, as well as for the advance in effective and precise therapeutic programs focused on the specific characteristics of problematic and disordered gambling patients.

**Authors' contribution:** Conceptualization, Susana Jiménez-Murcia; Data curation, Roser Granero and Susana Valero Solis; Funding acquisition, Susana Jiménez-Murcia and Fernando Fernández-Aranda; Investigation, Amparo del Pino-Gutiérrez, Gemma Mestre-Bach, Isabel Baenas, S.Fabrizio Contaldo, Mónica Gómez-Peña, Neus Aymamí, Laura Moragas, Cristina Vintró, Teresa Mena-Moreno, Eduardo Valenciano-Mendoza and Bernat Mora-Maltas; Project administration, José M. Menchón and Susana Jiménez-Murcia; Supervision, Susana Jiménez-Murcia; Writing – original draft, Roser Granero and Susana Jiménez-Murcia; Writing – review & editing, Fernando Fernández-Aranda and Roser Granero.

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## APPENDIX A. SUPPLEMENTARY DATA

Supplementary data to this article can be found online at <https://doi.org/10.1556/2006.2020.00028>.

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